CONVERSION OF POTATOES TO STABLE FORM[1]

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The greatest drawbacks to the industrial utilization of potatoes are their great bulk and perishability. The obvious way to overcome these is to convert the potatoes to stable form by drying. Consequently, the Department of Agriculture's Eastern Regional Research Laboratory has been engaged in engineering research on a pilot-plant scale to develop cheap methods of accomplishing this.

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What is so difficult about drying a potato? Those of you who have tried it on a commercial scale will have some ideas on that point. To begin with, you must evaporate about 4 pounds of water to get 1 pound of dry solids. So you decide to press out some of the water first and save drying costs. Then you find that you have lost nearly 20 per cent of the solids, and your reduced yield may have more than offset your savings in drying. Or perhaps you got into difficulty with the local authorities for putting the press effluents into the river. If your drying was done in a direct-heat drier without precautions to avoid a spark, you may have had a fire or an explosion from the finely divided starch. If you were fortunate enough to avoid these troubles, you no doubt observed that the ground potatoes rolled up into pellets the size of marbles, the insides of which remained soft and doughy even though you dried the outside to a crisp.

Perhaps, instead of grinding the potatoes you decided to slice them and use a direct-heat drier. Then you undoubtedly had the unpleasant experience of having the slices stick to the drier or stick to each other, forming lumps the size of footballs. But you don't want to hear about processes that fail; you want to know about the ones that function.

There are three physical forms in which a potato may be feasibly dried: raw ground, raw sliced, and cooked and mashed. Let us consider first grinding them raw.

Steam Tube Drier Process for Feed

Figure 1 shows a process for producing feed from raw ground potatoes with a steam tube drier. Here the potatoes unloaded from a box car are flushed by flume to a conveyer, which delivers them to a washer. This may be any one of a number of types. The one commonly used in starch factories is simple and efficient. It consists of a semi-cylindrical tank divided into compartments and partially filled with water. A shaft with agitators runs the full length of the tank, and paddles lift the potatoes from one compartment to the next. The clearance between the paddles and the shell is such that the stones are left in the trough and periodically removed with the dirt. The washed potatoes are ground in a hammer mill having ¼-inch holes in the screen. The ground product is delivered to a mixer conveyer, where a sufficient quantity of the dried product to achieve a moisture content not exceeding 45 per cent is incorporated with it. This is equivalent to recycling about 1.1 pounds of dried product for each pound of potatoes ground. This recycling is roughly analogous to refluxing part of the product obtained in fractional distillation.

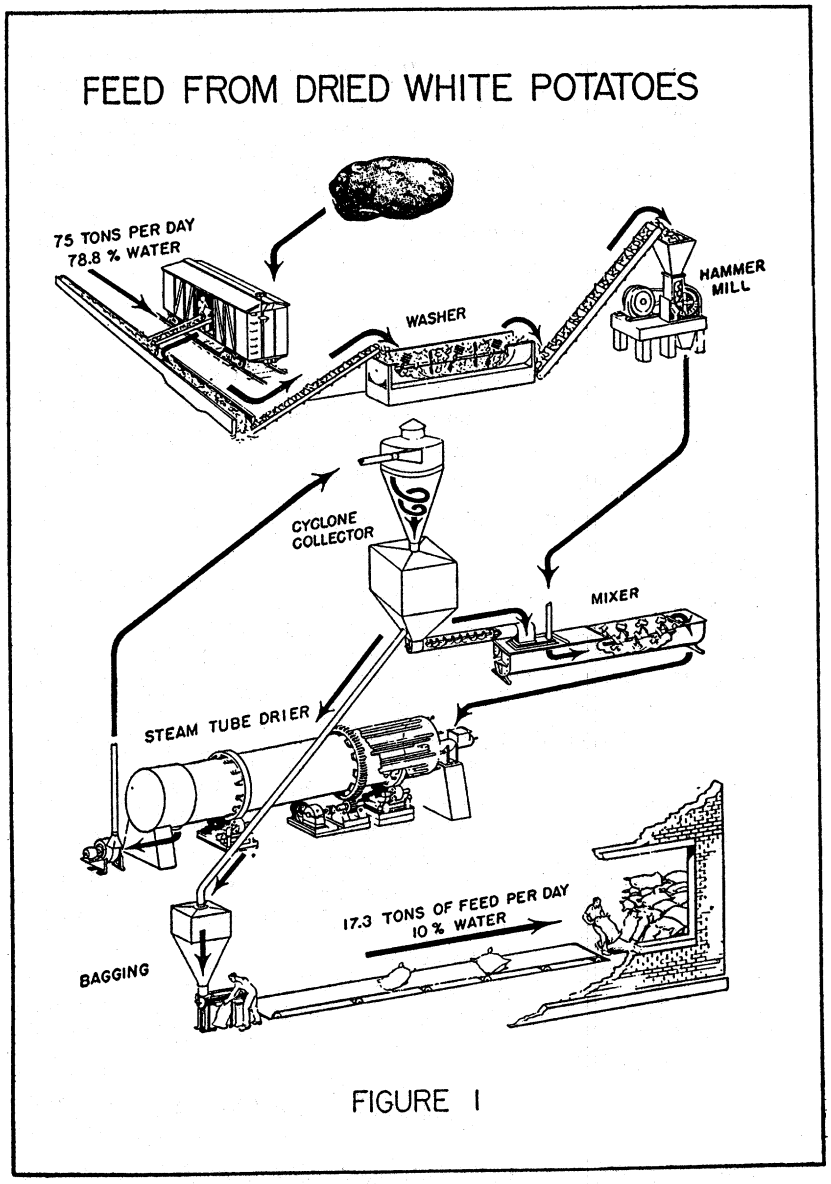

FIGURE 1

A thoroughly mixed product below 45 per cent moisture can be fed to a rotary steam tube drier without danger of sticking. Higher moisture contents cause the potatoes to coat the steam tubes, resulting in a mixture of burned and under-dried material. The entire product from

the drier is delivered by a blower through a cyclone to a bin. From the bottom of this bin, the proper proportion of the dried product is sent to the mixer conveyer. The speed of this small conveyer from the bottom of the bin is variable, as is the speed of the belt conveyer going to the hammer mill. The conveyers are adjusted to give the desired 45 per cent in the mixer conveyer. All the dried product not required for recycling automatically overflows from the bin and is bagged. The product is light brown and contains all the protein, minerals and carbohydrates that were in the potato.

Cost

We have estimated that a plant capable of processing 75 tons of potatoes per 24-hour day could be built for an investment of $80,000. Such a factory would produce a little more than 17 tons per day of feed at a cost of slightly more than $24.00 per ton. This figure represents all costs except that of the potatoes and selling costs for the product.

Steam Tube Drier Process for Flour and Meal

Figure 2 shows how this basic method with slight modification can be adapted to the production of potato flour. The differences between this picture and the one you have just seen are (1) an inspection table to eliminate bad potatoes, as the product will be used for food; (2) an agitated tank for sulfur dioxide; and (3) facilities for grinding and screening the dried product to produce flour and meal. The amount of sulfur dioxide required to give between 200 and 500 ppm in the flour is about .075 per cent of the weight of the potatoes. Even this small quantity will cause some corrosion, but this will occur almost entirely in the exhaust duct system from the steam tube drier. For long life this duct should be made of stainless steel.

To insure preservation of the dried food product, its moisture content must not exceed 9 per cent, whereas in feed the moisture content may be as high as 12 per cent. The dried food product will be very light cream in color. It is ground in a hammer mill and screened through a 30-mesh screen superimposed over a 70-mesh screen. The product passing through 70-mesh is flour; that held on the 70-mesh screen and passing through the 30-mesh is meal. The little that remains on the 30-mesh is returned to the hammer mill for regrinding.

Cost

A factory processing 75 tons of potatoes per day into flour or meal by this method would cost about $87,500. It would produce between 16

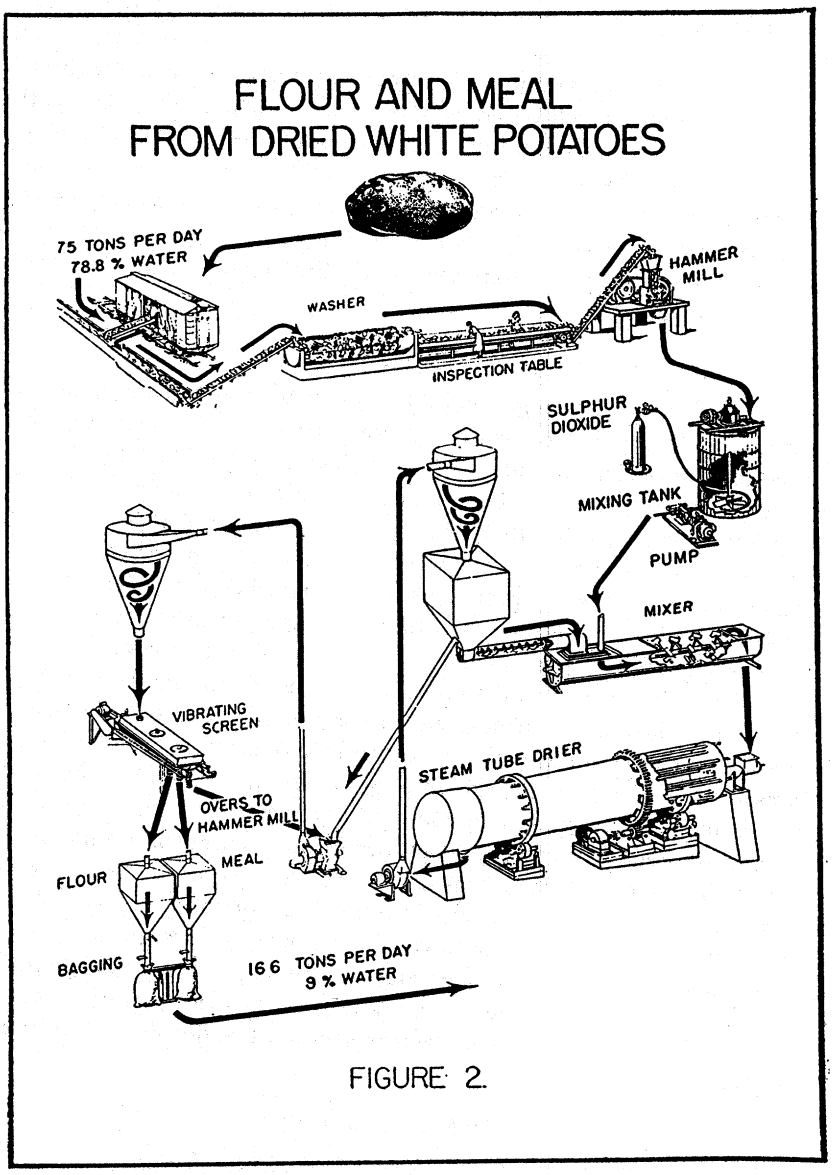

FIGURE 2.

and 17 tons per day, and the over-all cost of the product would be about $39.00 per ton, including all costs except that of the potatoes and the selling costs. Even if the price of potatoes were included, the cost of making the product would be considerably less than that of the conven-

tional process using cooked potatoes and drum driers. Is the product as good? Its color is only slightly on the cream side, as compared with the standard product, and it is entirely satisfactory for use in dehydrated soups, into which much of the material will go that is required by the Commodity Credit Corporation for European uses. We do not yet know what quality bread it will make, but we suspect it may have different properties from standard potato flour, as it was made from raw potatoes instead of cooked potatoes. We hope later to have more information on this point from the U. S. Bureau of Home Economics and Human Nutrition.

Pressing

At this point one might logically inquire why in these processes for producing feed and food with a steam tube drier, pressing cannot be used to remove some of the water and reduce drying costs. This has been done successfully, and the flour made from pressed potatoes is probably slightly lighter in color than that from unpressed potatoes. However, approximately 20 per cent of the solids are lost by pressing, including nearly 50 per cent of the protein as well as valuable materials and carbohydrates. The press effluent constitutes a disposal problem, and the cost of pressing may be greater than the savings which it achieves.

Figure 3 shows what the process would be if pressing were included. You see a cider press substituted for the recycling device. There is no need to recycle, if the moisture content is reduced to 56 per cent by pressing. With the elimination of some of the sugars and proteins, there is less tendency to stick, and consequently there is no necessity for reducing the moisture content to 45 per cent. Continuous rotary presses cannot be used, as it is not feasible to reach a moisture content of 56 per cent by that means. SO_2 must be used for pressing instead of lime when the product is for food use. The amount required is 0.2 per cent based on the weight of the potatoes. The method depicted here has been used on a commercial scale, and a good product produced, but we estimate that pressing would increase the cost about $2.00 per ton of product.

Direct Heat Driers

We should not leave the discussion of drying ground, raw potatoes without mentioning the possibility of using a high-temperature, direct-heat rotary drier. It is entirely possible to use such a drier when the moisture content of the feed is reduced by pressing or recycling to the point where it will not stick. However, there can be an element of hazard here because of the explosive properties of finely divided starch

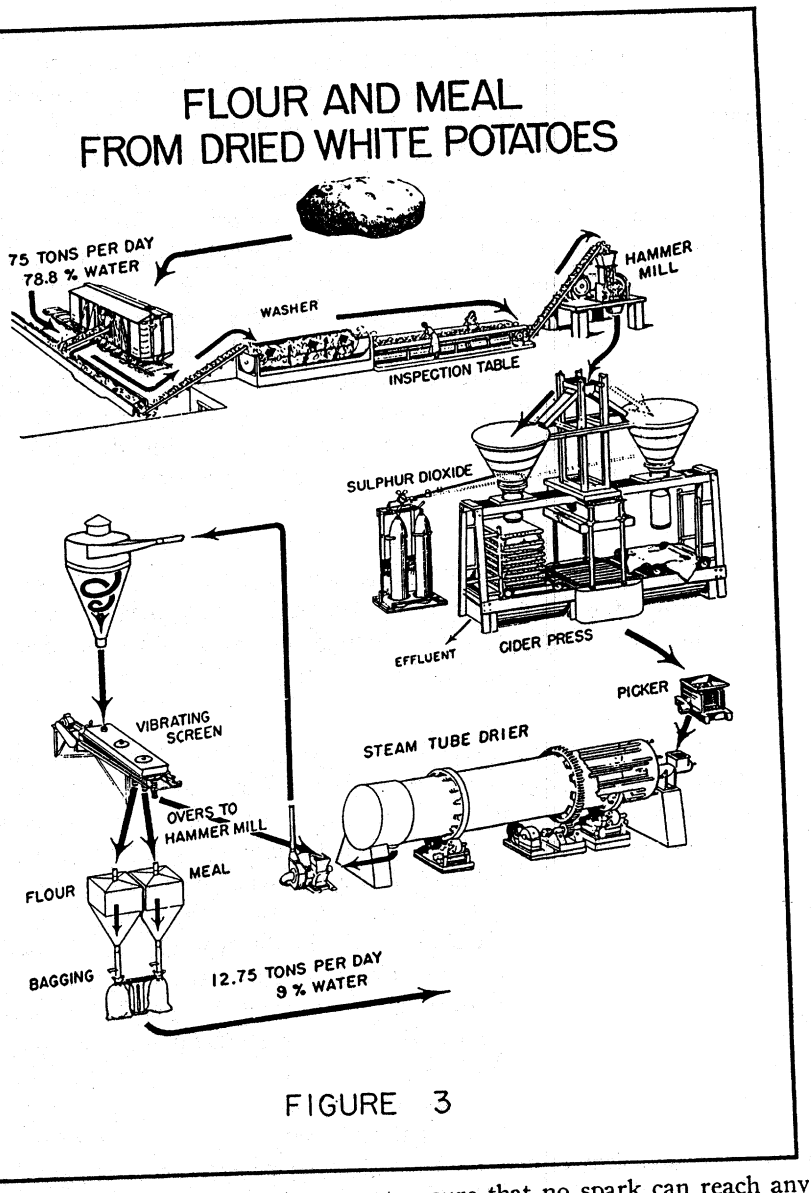

FIGURE 3

suspended in air. Precautions must ensure that no spark can reach any explosive starch-air mixtures that may exist.

Sliced, Raw Potatoes

We have just mentioned the hazard which can be involved in the direct-heat drying of raw ground potatoes. Why not then cut them into

small, uniform slices to minimize the release of starch and dry them in direct-heat driers? Any one who has tried this will know the difficulties encountered because the potatoes stick to the drier. Even though this may be prevented, the slices tend to case harden and to dry very slowly on the inside. The Germans, however, during the last war, succeeded in drying sliced potatoes in direct-heat beet pulp driers. After soaking, this product was cooked and served to the German Navy. During the survey of European practices for potato utilization we found that they solved the sticking problem by slicing the potatoes uniformly and coating them with ground dried potato. Following this idea and utilizing a drier of domestic manufacture, we have overcome the sticking difficulty and succeeded in drying potato slices. These may be ground to produce feed, or if the color is maintained with sulfur dioxide the product will be satisfactory for certain grades of potato flour.

Cost

We do not yet have enough specific data to make reliable cost estimates on direct heat drying of sliced potatoes, but we believe it will be somewhat higher than that of drying them ground in a steam tube drier.

Cooked Potatoes

The third form in which potatoes may be feasibly dried is after cooking and disintegrating. Last July when the Commodity Credit Corporation invited bids on potato flour in a quantity more than 10 times our normal capacity, the Eastern Regional Research Laboratory was faced with the problem of finding other means whereby existing equipment could be utilized. Figure 4 shows one process developed. It consists merely of adapting double-drum driers of the type commonly used for drying distiller's solubles. Although drum driers are conventionally used for making potato flour, they are of different design. The drums rotate upward and away from each other at their nearest point of contact, and the thickness of the mat on the drum is controlled by superimposed small-diameter rollers. In adapting distillery drum driers, the problem was to deposit uniformly a layer of the cooked potatoes on the drums. In this case, the drums have no superimposed rollers, and they rotate downward and away from each other at their nearest point of contact. The thickness of the layer is determined by the clearance between the rolls.

The solution to the problem proved comparatively simple. If the cooked potatoes, while kept at a temperature about 150° F., are passed through a hammer mill to reduce them to a smooth creamy consistency

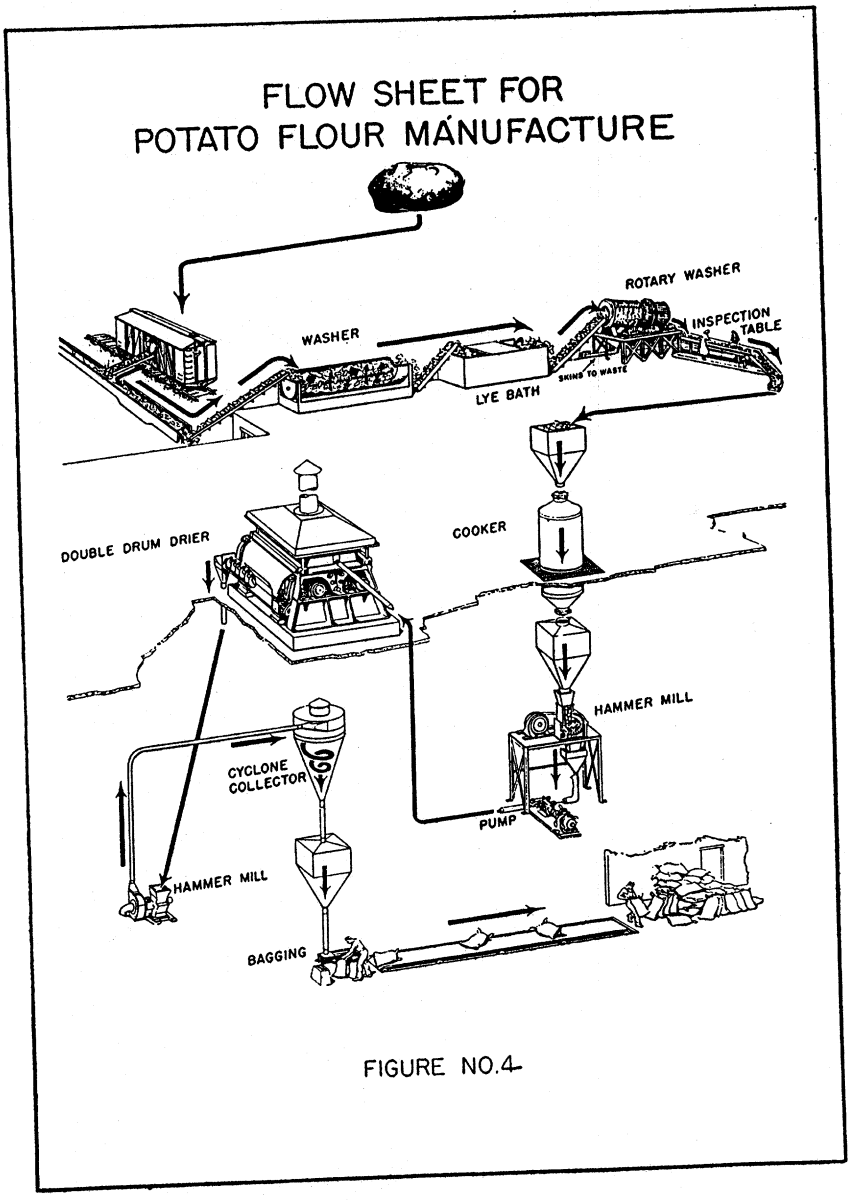

FIGURE NO.4

and, while still hot, are fed to the drum drier, a uniform layer is deposited on the drums.

This principle is being used by large distillers today to meet the emergency demand for potato flour.

Summary

Ground, raw potatoes may be dried with or without pressing in either steam tube driers or direct heat driers, but the former are generally safer. The product can be used for food or with slight modification for certain grades of flour.

Sliced potatoes if coated with a small amount of dried ground potatoes may be dried in direct-heat rotary driers to produce food or certain grades of flour. The process is safe but probably slightly more expensive than drying ground potatoes in steam tube driers.

Finally, drum driers of the type used for distillers, solubles, and other products may be used for making potato flour.